Overview Global Climate Change Impacts in the United States

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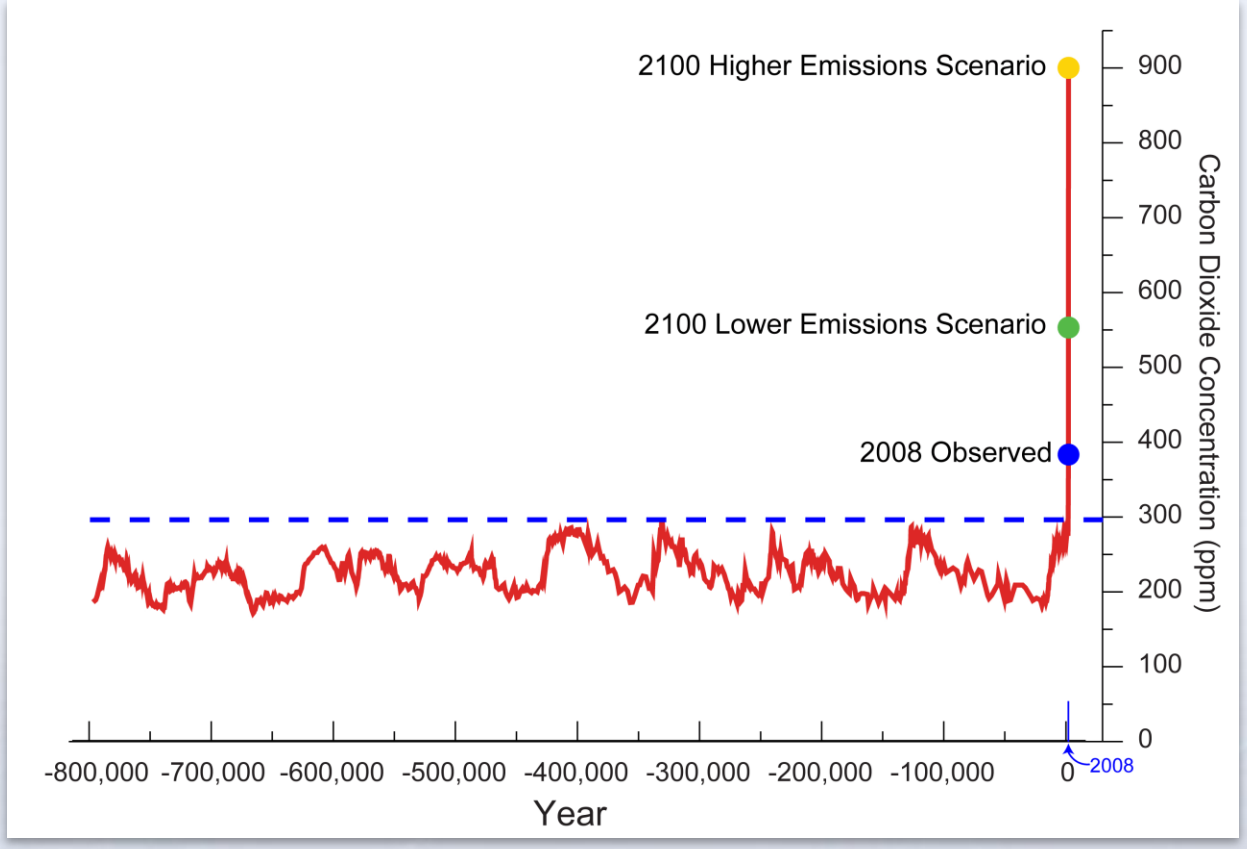
Outline of this Talk

- Goal: summarize global and national climate change and its impacts in the United States
- The talk will follow the 10 Key Findings
  - And weave the important and relevant information around them
- Note that the report examines 7 sectors and 9 regions
  - Sectors: Water Resources, Energy, Transportation, Agriculture, Ecosystems, Human Health, Society
  - Regions: NE, SE, Midwest, Great Plains, SW, NW, Alaska, Islands and Coasts

1. Global warming is unequivocal and primarily human-induced

Moving Outside the Range of Historical Variation

800,000 Year Record of Carbon Dioxide Concentration

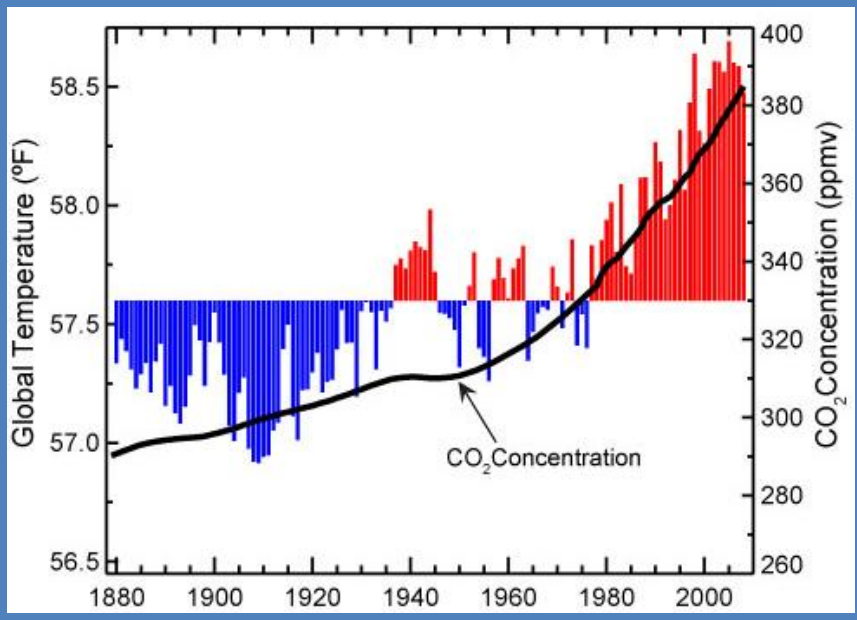


1. Global warming is unequivocal and primarily human-induced

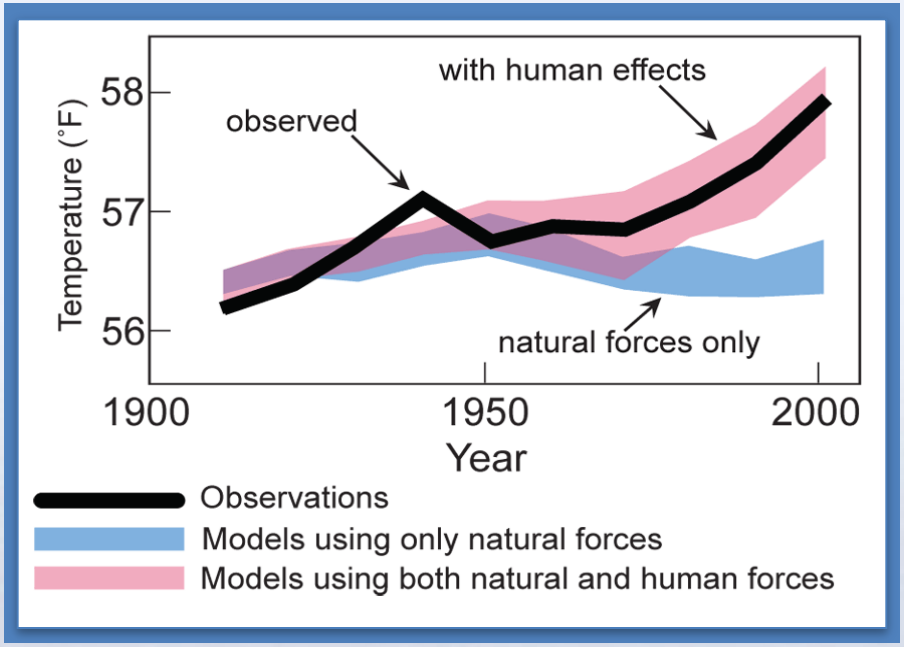
Human fingerprints have been identified in many aspects of climate change

- Temperature
- Precipitation
- Ocean heat content
- Atmospheric moisture
- Arctic sea ice

Global Temperature and CO_2

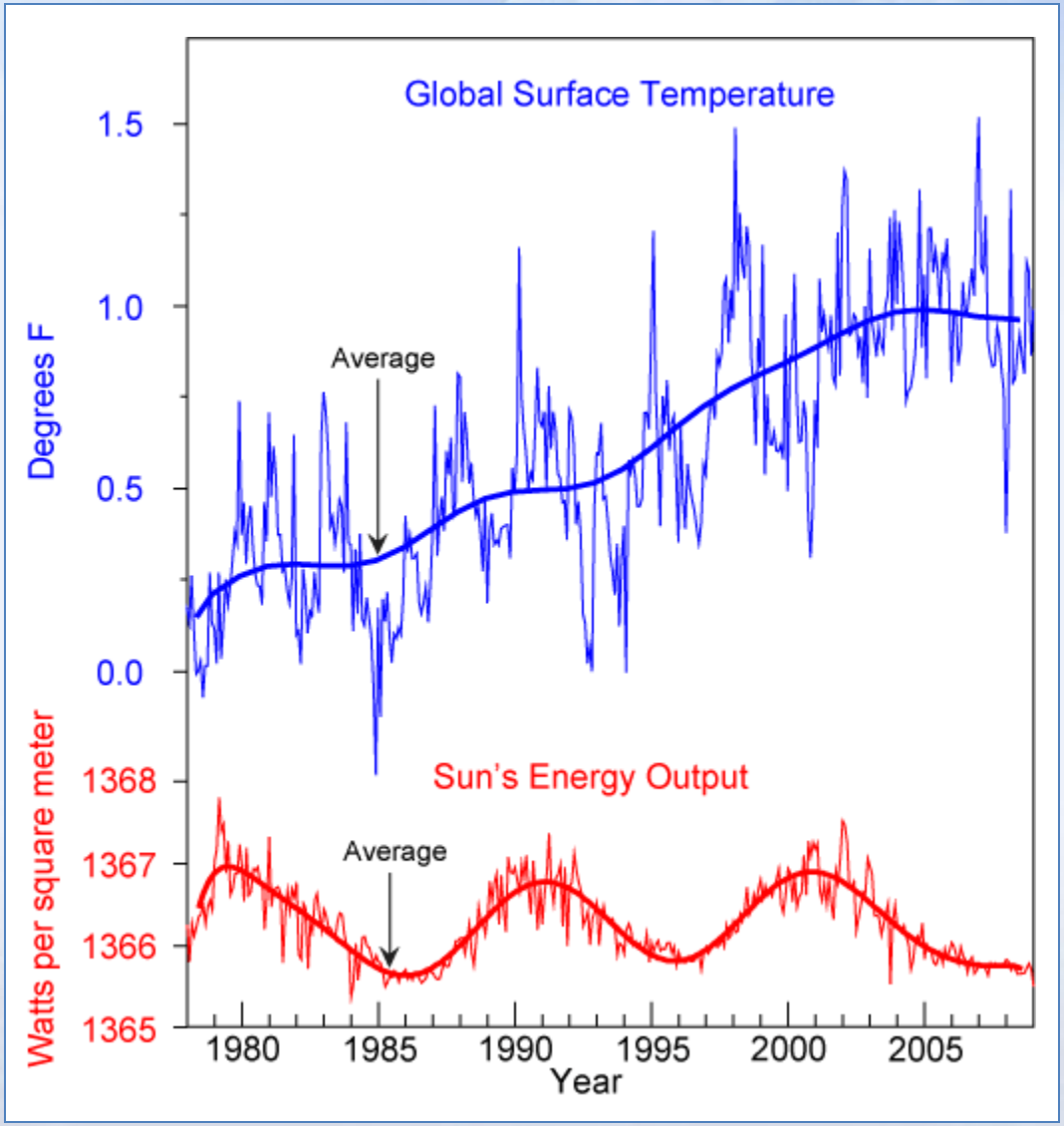


Separating Human and Natural Influences on Climate

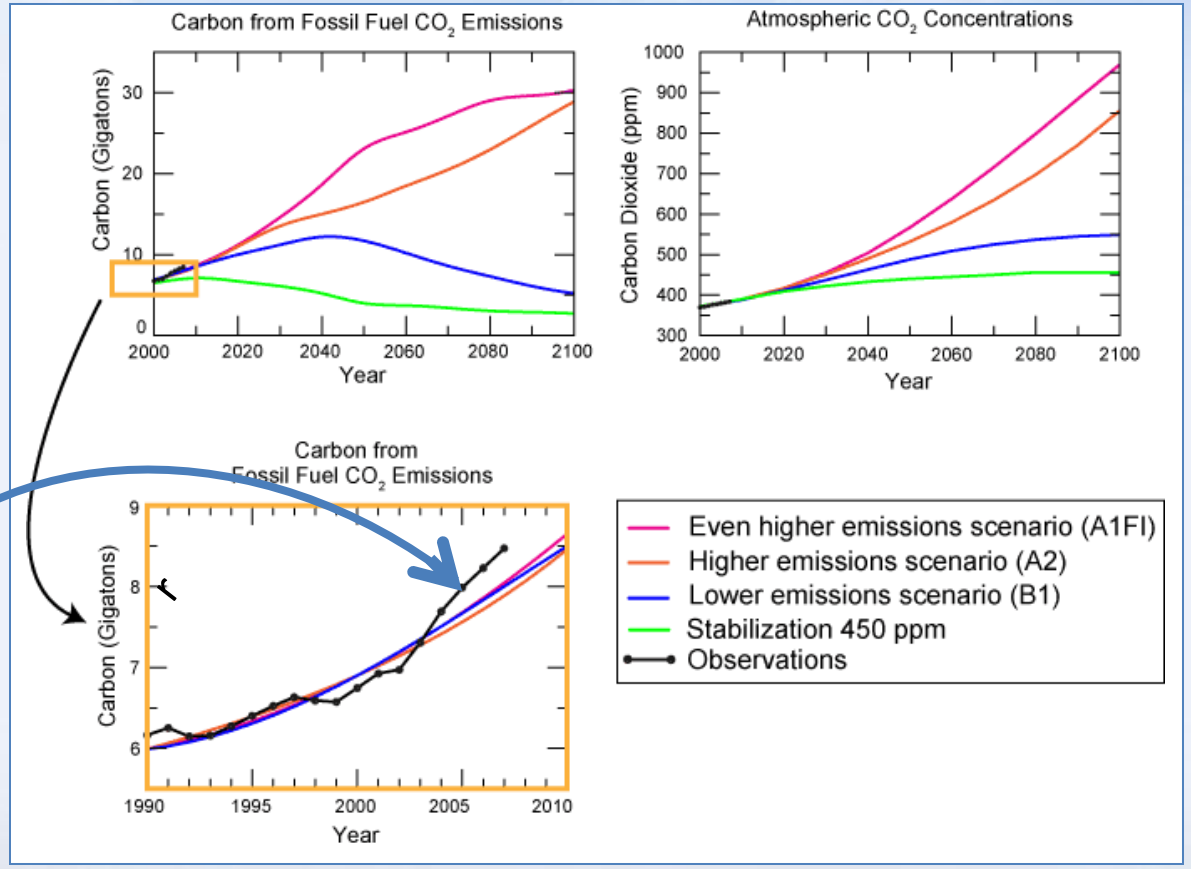


1. Global warming is unequivocal and primarily human-induced

- The sun's total energy output has actually decreased slightly as temperature has increased



2. Climate changes are underway in the U.S. and are projected to grow



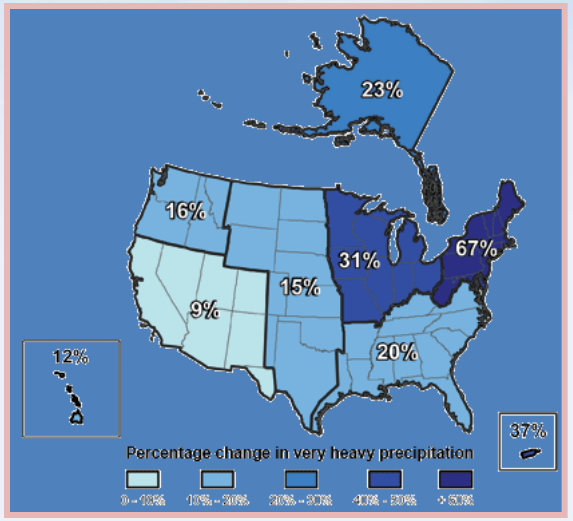
- Recent carbon dioxide emissions are, in fact, above the highest emissions scenario developed by the IPCC

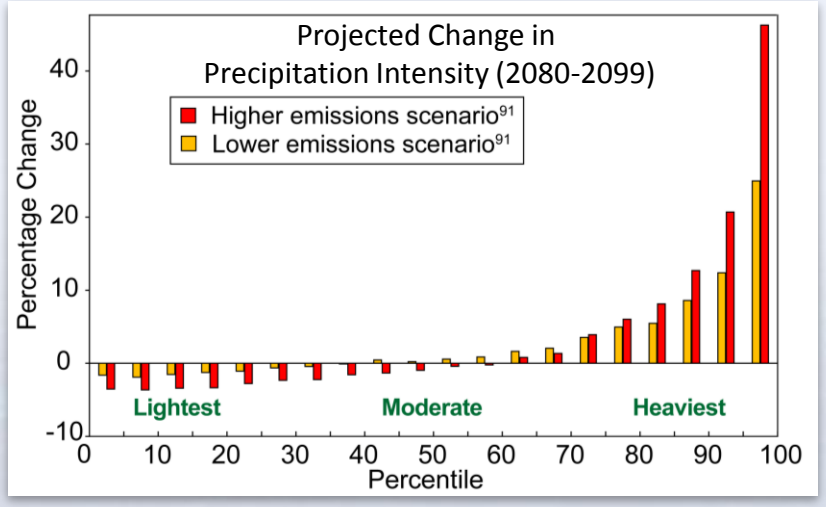
- About 1/3 of the CO_2 from fossil fuel burning remains in the atmosphere after 100 years
- About 1/5 of it remains after 1000 years

2. Climate changes are underway in the U.S. and are projected to grow

- Temperature rise
- Sea-level rise
- Increase in heavy downpours
- Rapidly retreating glaciers
- Thawing permafrost
- Longer growing season
- Longer ice-free season in the ocean and on lakes and rivers
- Earlier snowmelt
- Changes in river flows

Observed Increases in Very Heavy Precipitation (1958 to 2007)



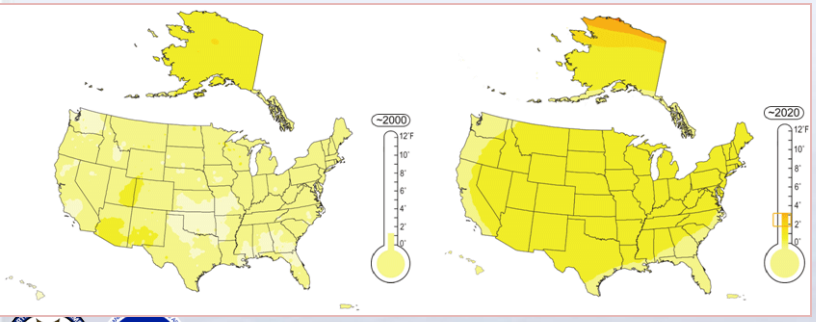


2. Climate changes are underway in the U.S. and are projected to grow

Significant impacts on:

- Water resources
- Energy supply and use
- Transportation
- Agriculture
- Ecosystems
- Human health
- Society

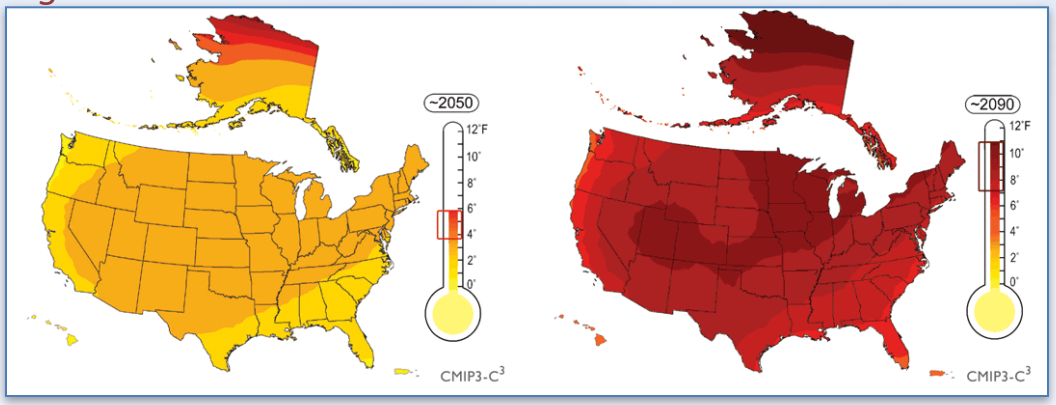
Present-Day Change (1993-2007) | Near-Term Projected Change (2011-2029)



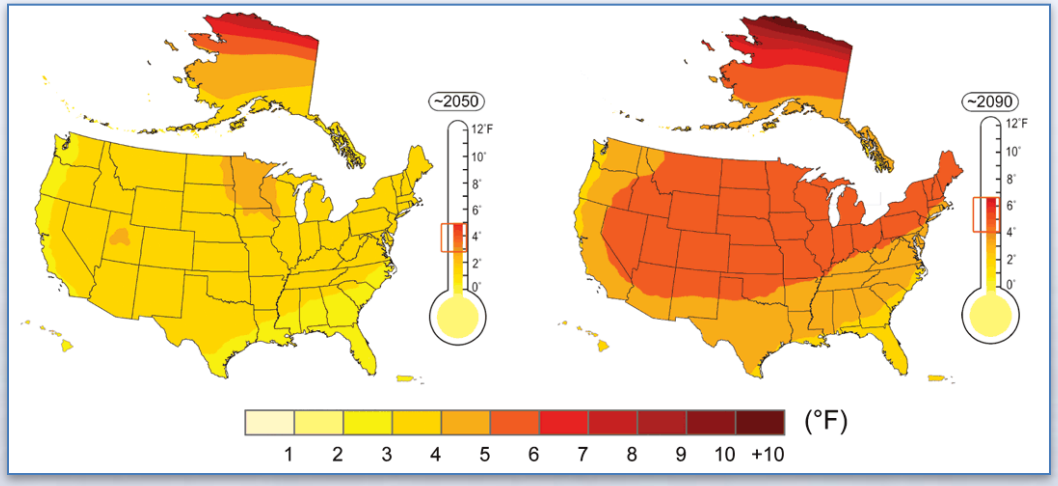
Projected Temperature Change (°F)
from 1961-1979 Baseline

Mid-Century (2041-2059 average) | End of Century (2081-2099 av.)

Higher Emissions Scenario



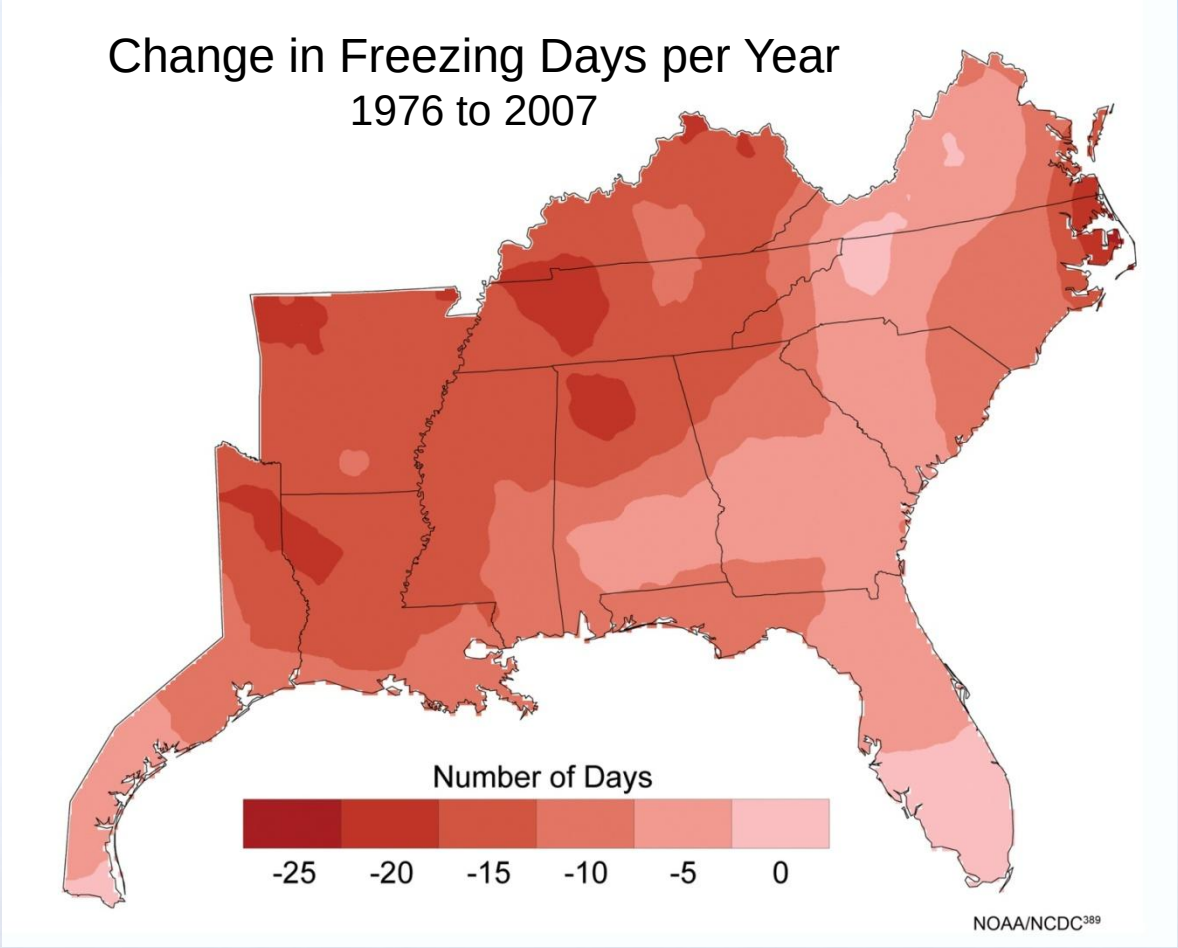
Lower Emissions Scenario



2. Climate changes are underway in the U.S. and are projected to grow

- Number of days that dip below freezing – declined across the Southeast since the 1970s

- Climate models project continued warming across the region



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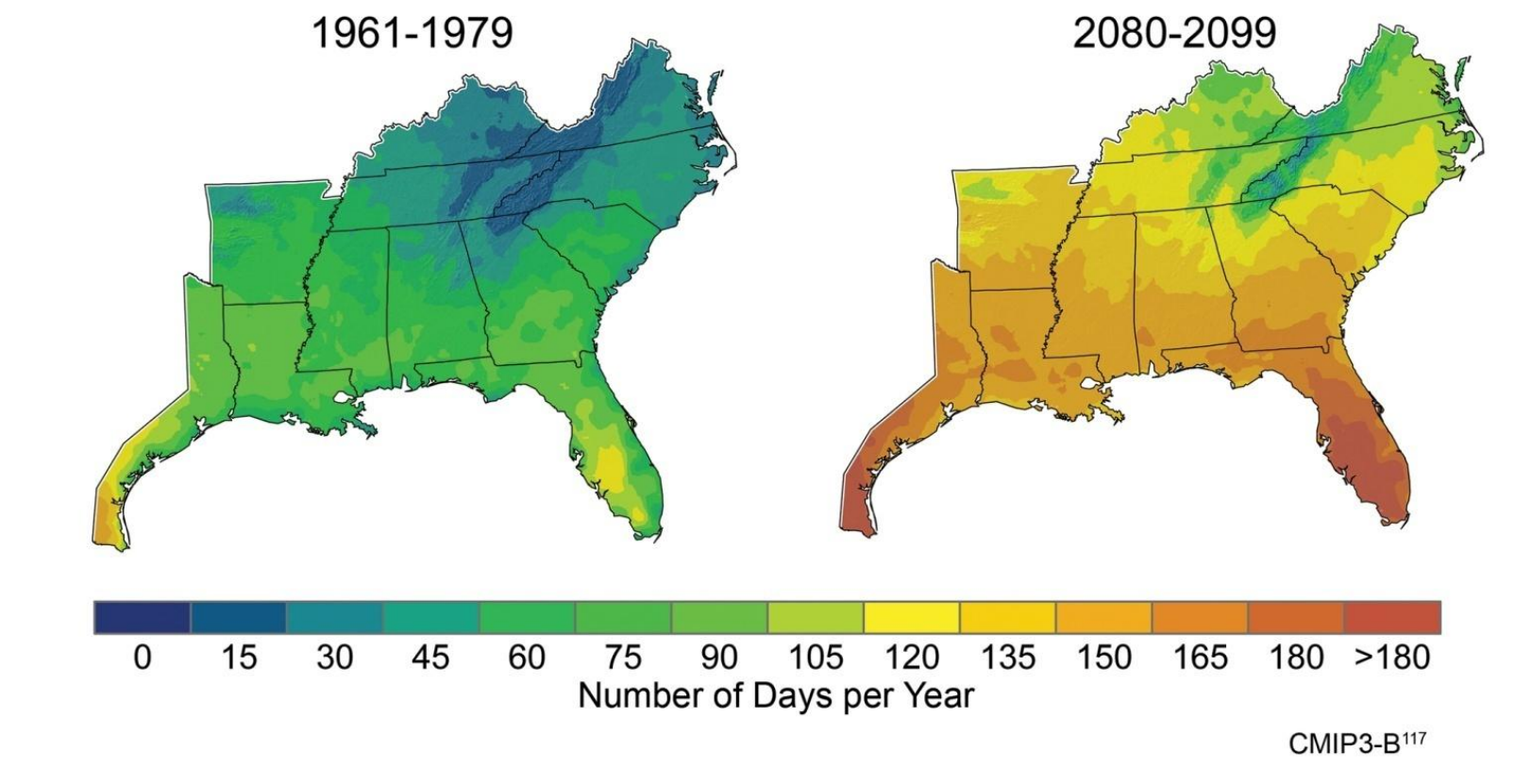
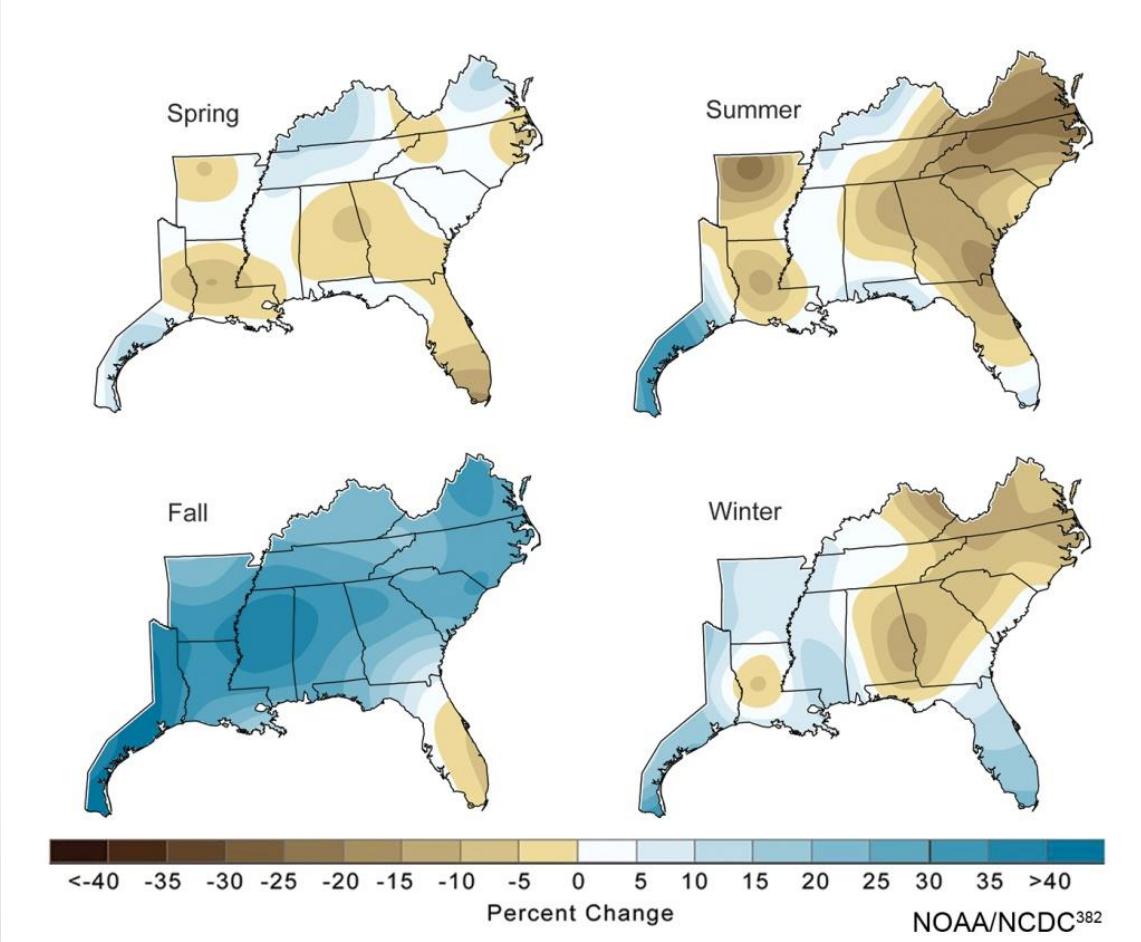


Number of Days per Year with Peak Temperature over 90 Degrees

2. Climate changes are underway in the U.S. and are projected to grow

- Average increase of 30% in fall precipitation across region
- Significant summer declines in eastern areas
- The percentage of Southeast in drought has increased over recent decades

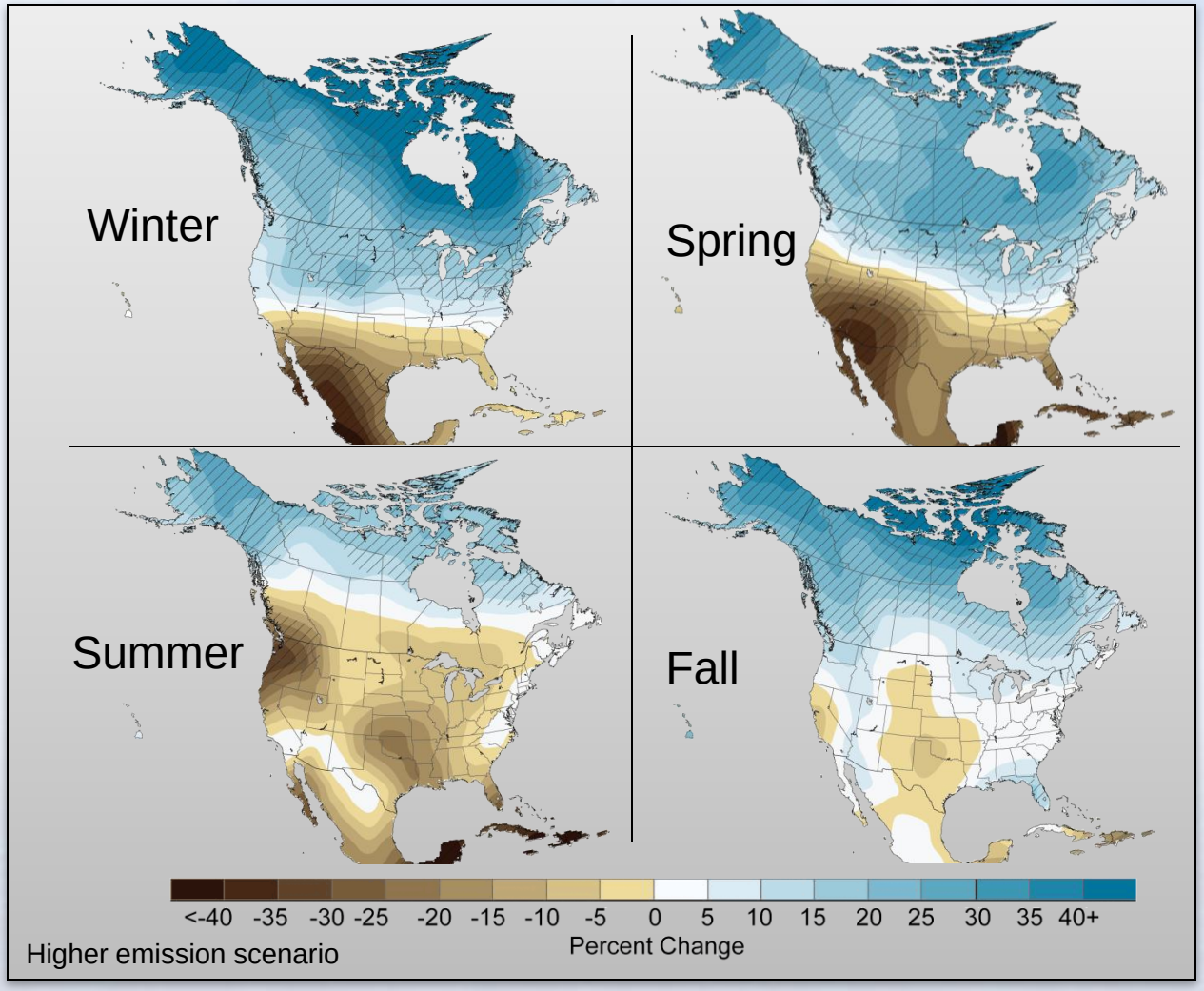


Observed changes in precipitation from 1901 to 2007

2. Climate changes are underway in the U.S. and are projected to grow

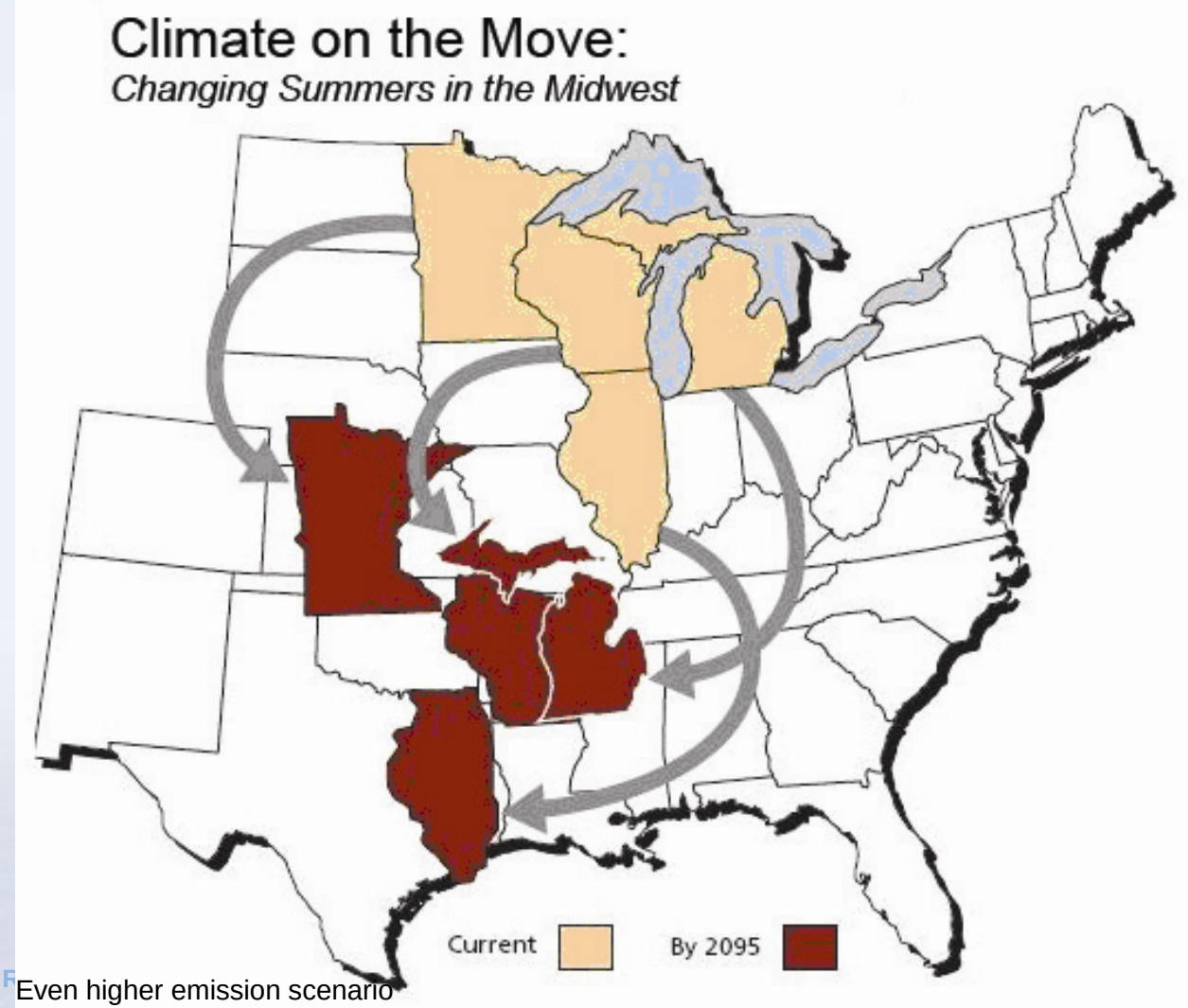
- Confidence in precipitation projections generally lower than for temperature
- Good confidence in overall pattern (wetter north, drier south)
- Less confidence in exact location of transition

Projected Change in Precipitation by 2080-2099



2. Climate changes are underway in the U.S. and are projected to grow

- Not just from climate A to climate B, but continuing to change beyond 2100.
- Rate of change is a big concern
  - Faster poses more problems than slower
- The magnitude of potential climate change can impact many aspects of society and the natural world.



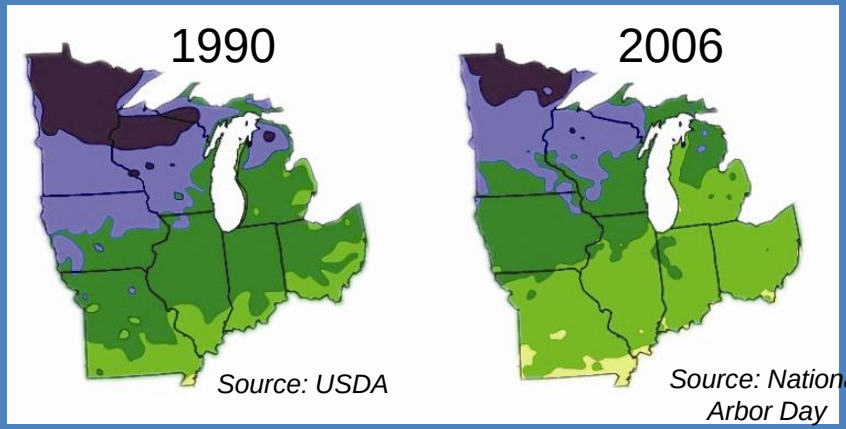
Even higher emission scenario

3. Widespread climate-related impacts are occurring now and are expected to increase

Your own backyard

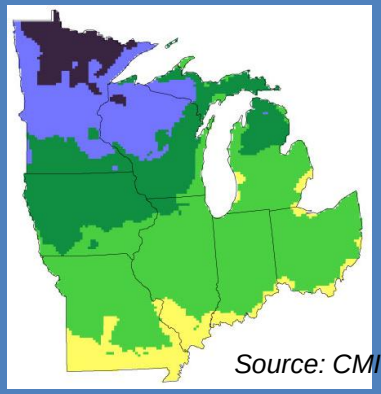
Major shifts in species are expected, such as maple-beech-birch forests being replaced by oak-hickory in the Northeast. Insect infestations and wildfires are projected to increase as warming progresses.

Observed and Projected Changes in Plant Hardiness Zones



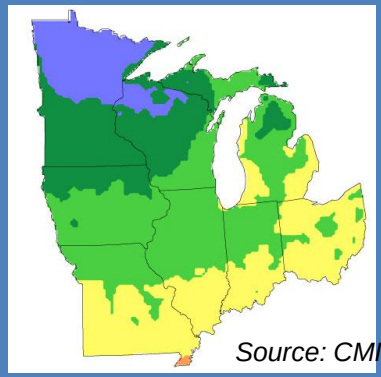
Source: USDA

Source: National Arbor Day Foundation



Source: CMIP-3

Lower Emissions Scenario by 2090



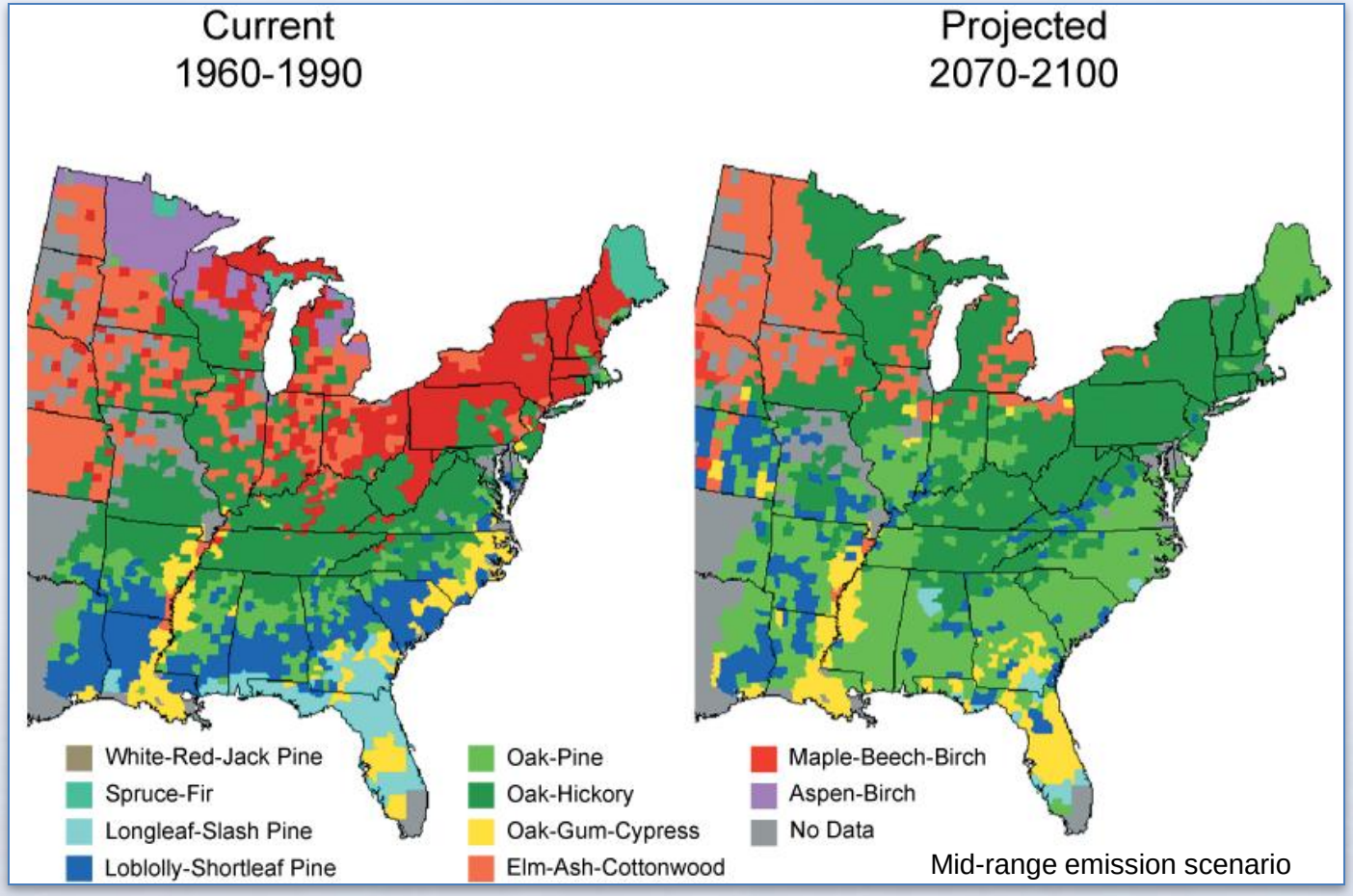
Source: CMIP-3

Higher Emissions Scenario by 2090

3. Widespread climate-related impacts are occurring now and are expected to increase

Ecosystems, Quality of Life

Projected Shifts in Forest Types

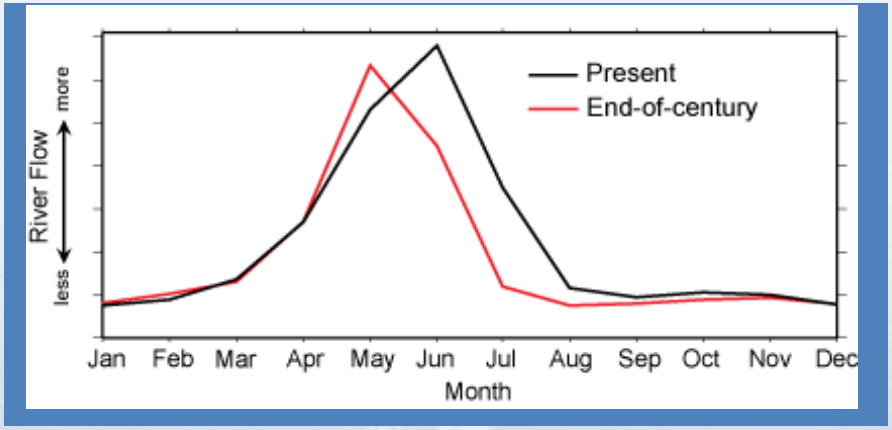


4. Climate change will stress water resources

- Less snow, more rain
- Wet areas get wetter – floods
- Dry areas get drier – drought
- Declines in mountain snowpack
- Increased competition for water
- More evaporation

In snowmelt-dominated streams, runoff peak will shift to earlier in the spring and late summer flows will be lower.

Simulated Changes in Annual Runoff Pattern



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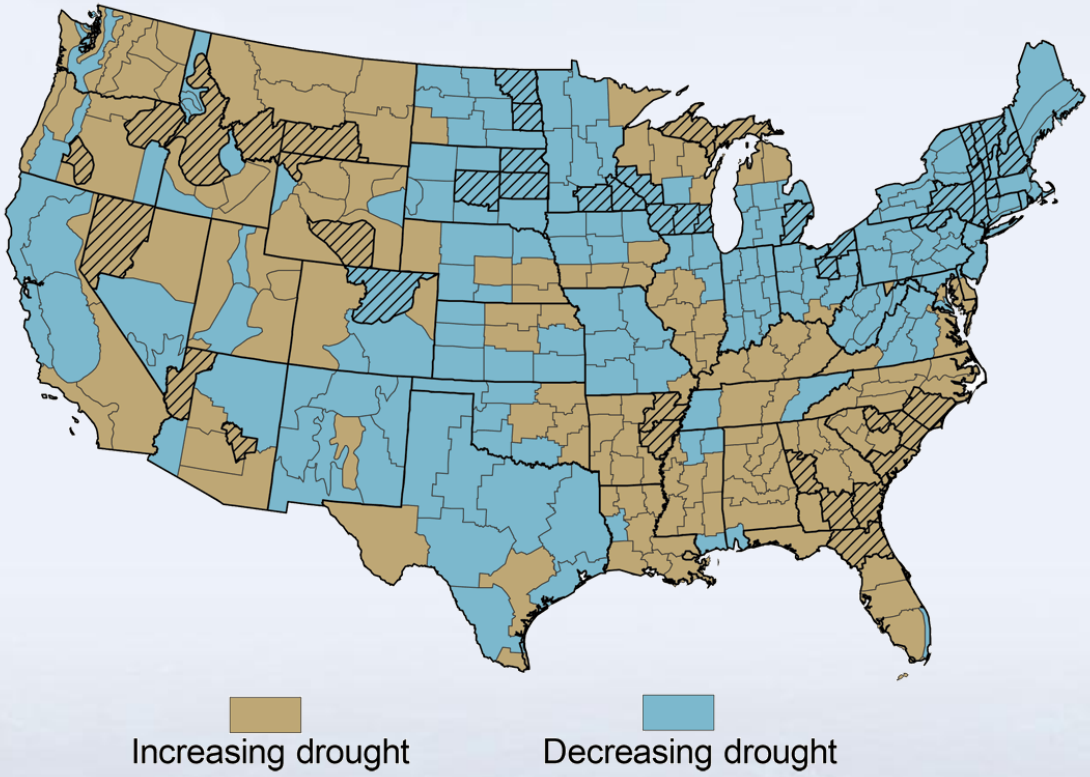
Observed Drought Trends 1958-2007

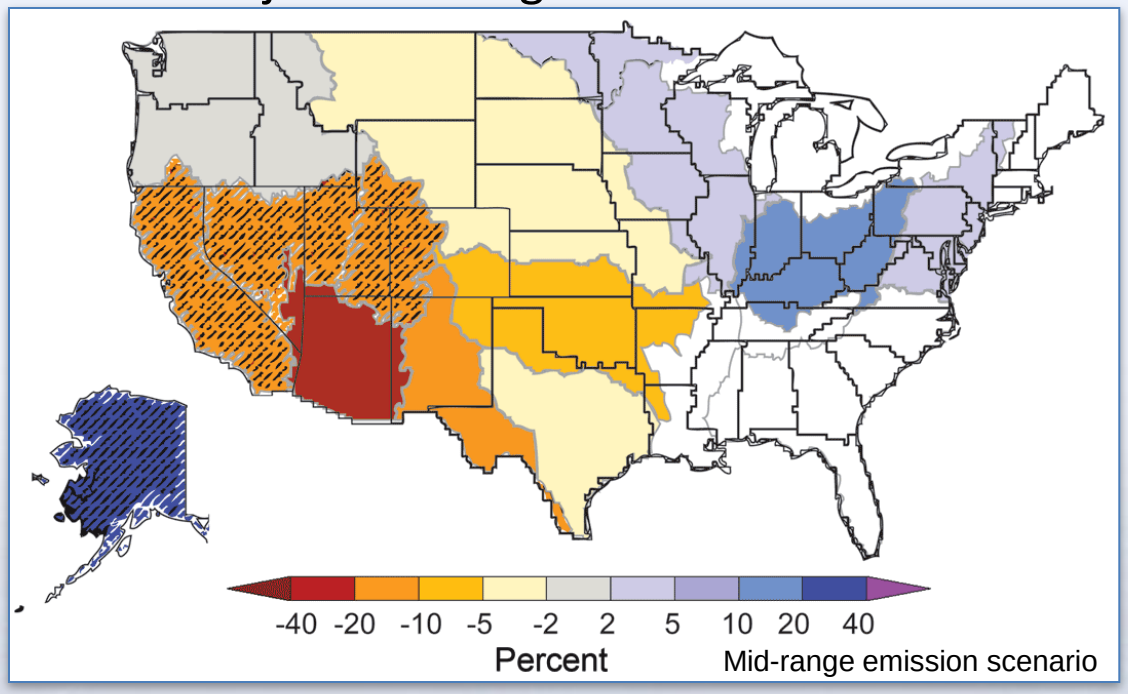
As warming increases competition for water, the energy sector will be strongly affected as power plants require large amounts of water for cooling.



4. Climate change will stress water resources

- Reduced summer runoff, increased winter runoff, and increasing demands will compound current stresses on water supplies and flood management, especially in the West
- Implications for many sectors
  - Agriculture
  - Human health
  - Ecosystem management
  - Energy

Projected Changes in Annual Runoff



5. Crop and livestock production will be increasingly challenged

Impacts for commercial agriculture, landscaping, and back yard gardeners

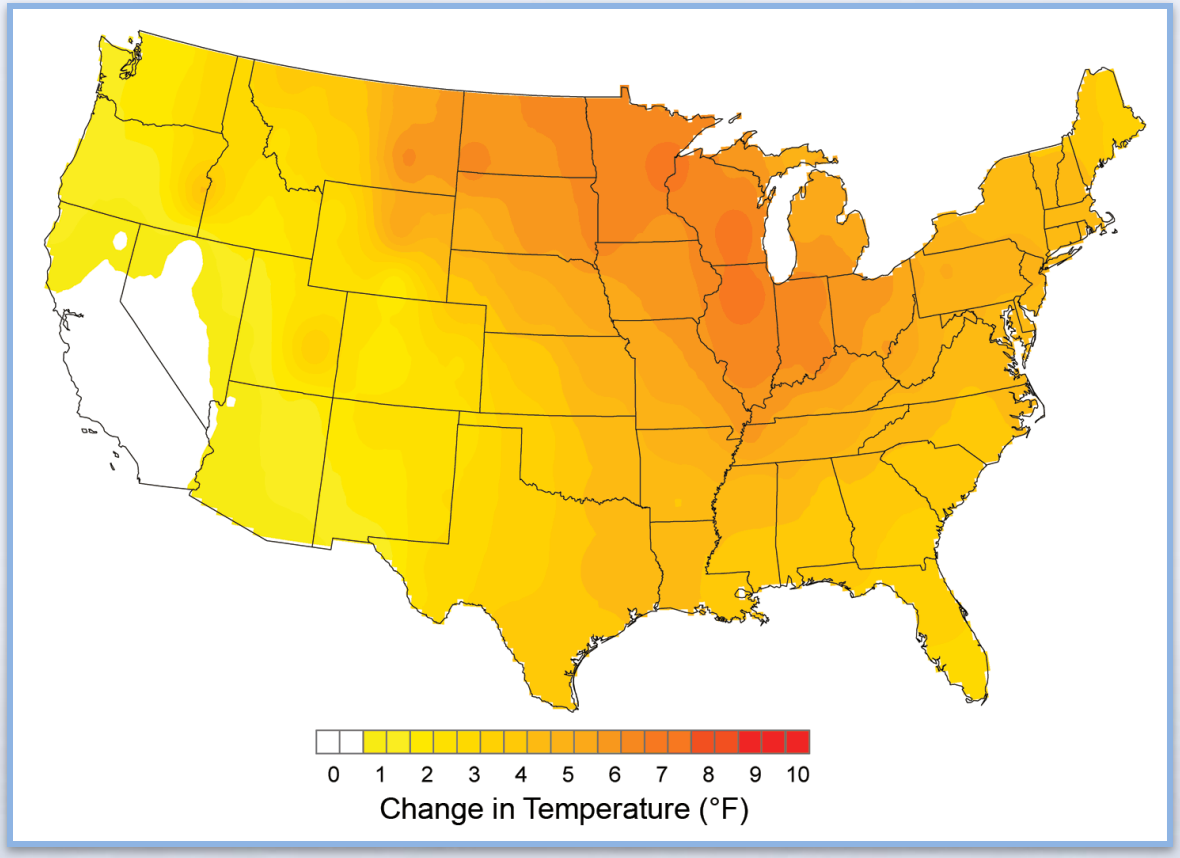
- Higher levels of CO_2 generally cause plants to grow larger
  - But often less nutritious
    - Particularly pastures
- Many weeds respond well to increasing CO_2
- Increasing CO_2 also makes some plants more water efficient.
- Extreme events (heavy downpours and droughts) likely to reduce crop yields
- Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

Increasing CO_2 Reduces Herbicide Effectiveness

5. Crop and livestock production will be increasingly challenged

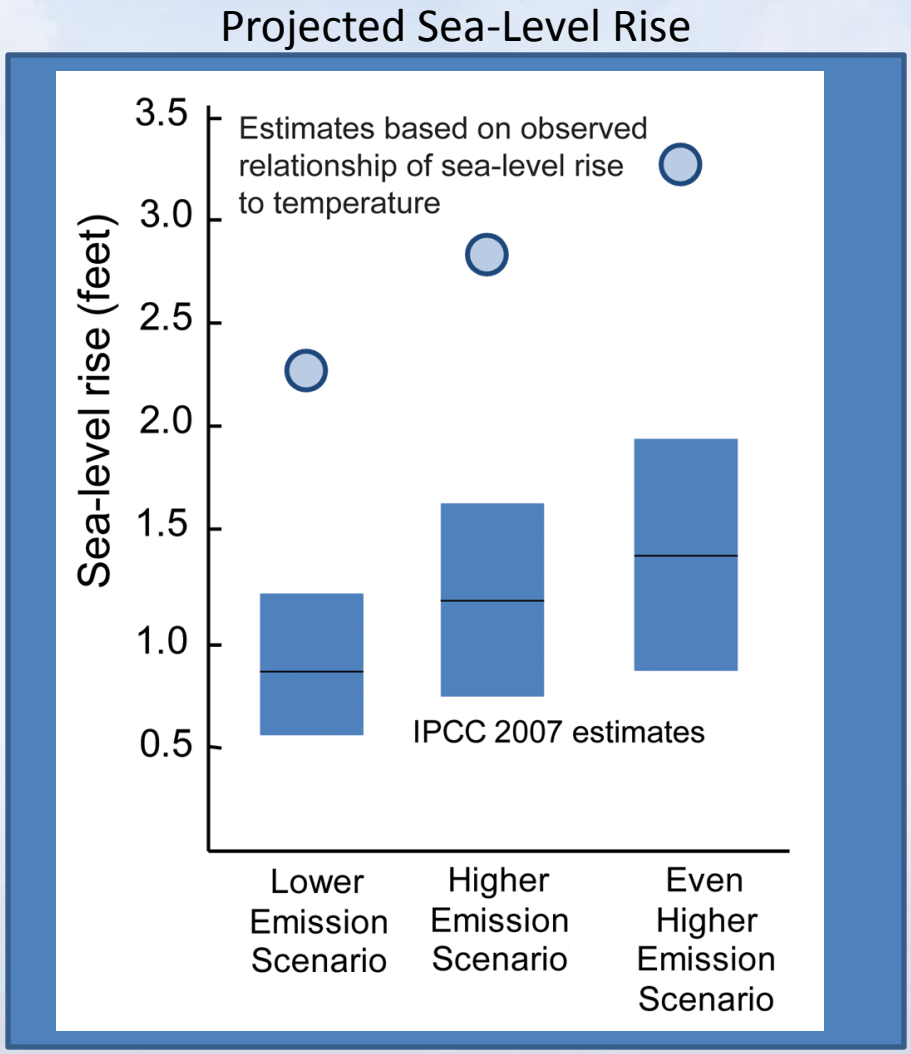
- Winter temperatures rising faster than in any other season, especially in many key agricultural regions
- This allows many insect pests and crop diseases to expand and thrive

Winter Temperature Trends
1975-2007



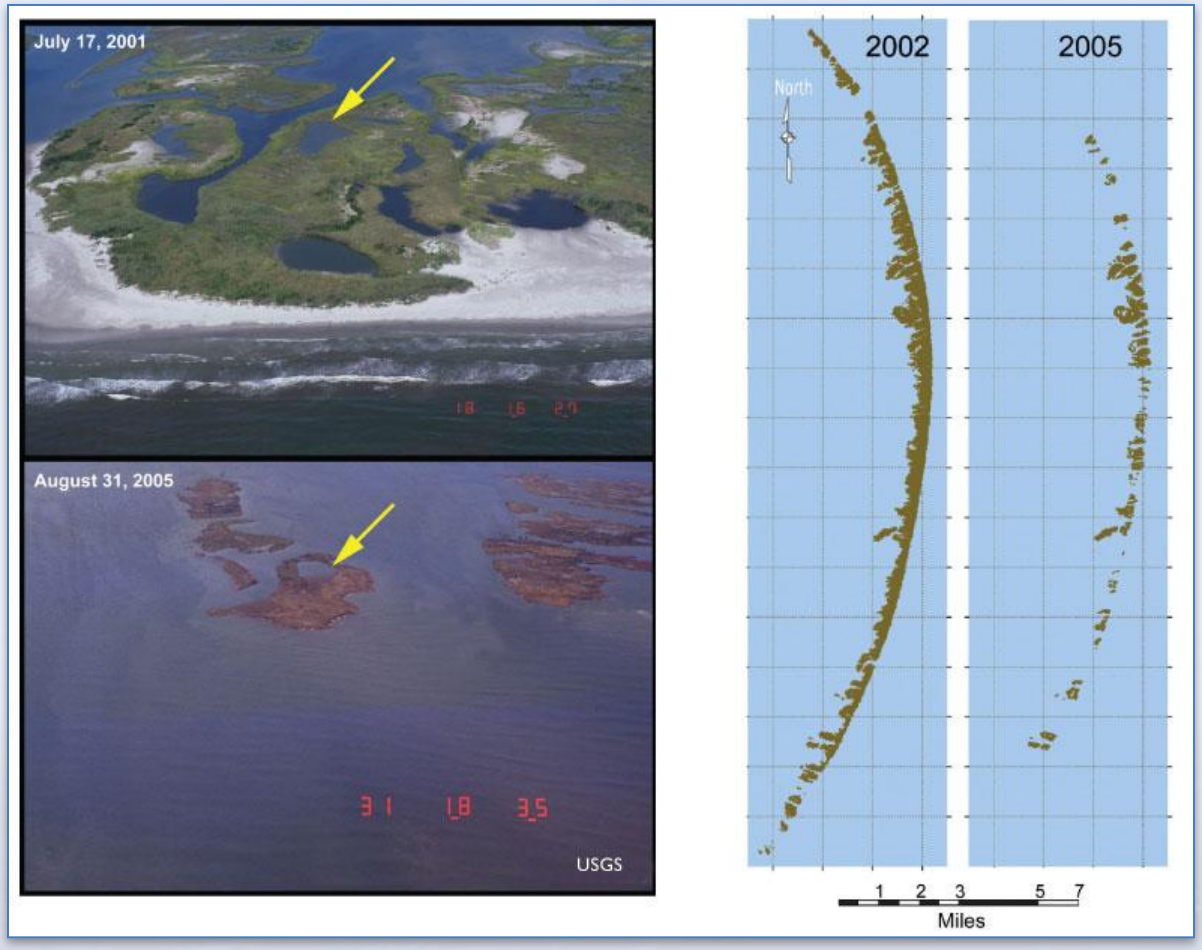
6. Coastal areas are at increasing risk from sea-level rise and storm surge

- Sea-level rise
- Storm surge
- Erosion
- Flooding



6. Coastal areas are at increasing risk from sea-level rise and storm surge

Land Lost During 2005 Hurricanes

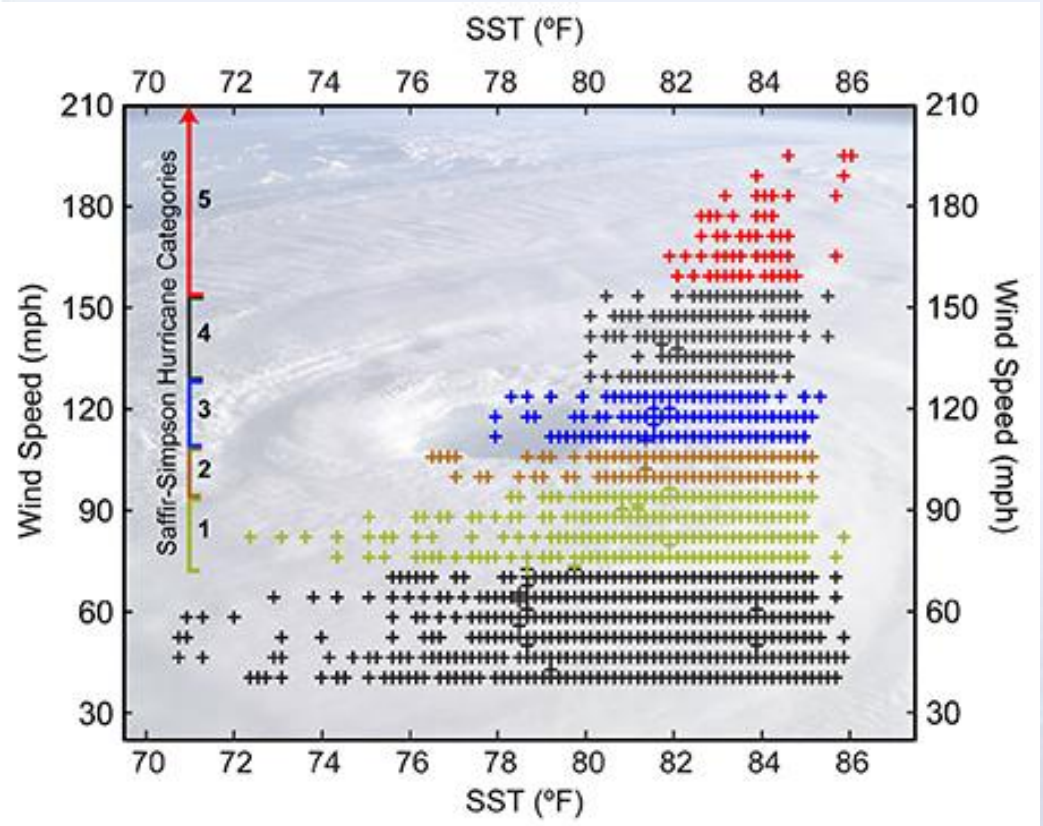


Chandeleur Islands, east of New Orleans, before and after the 2005 hurricanes

217 square miles, 85% of the island's land mass was lost

6. Coastal areas are at increasing risk from sea-level rise and storm surge

A bit about hurricanes…



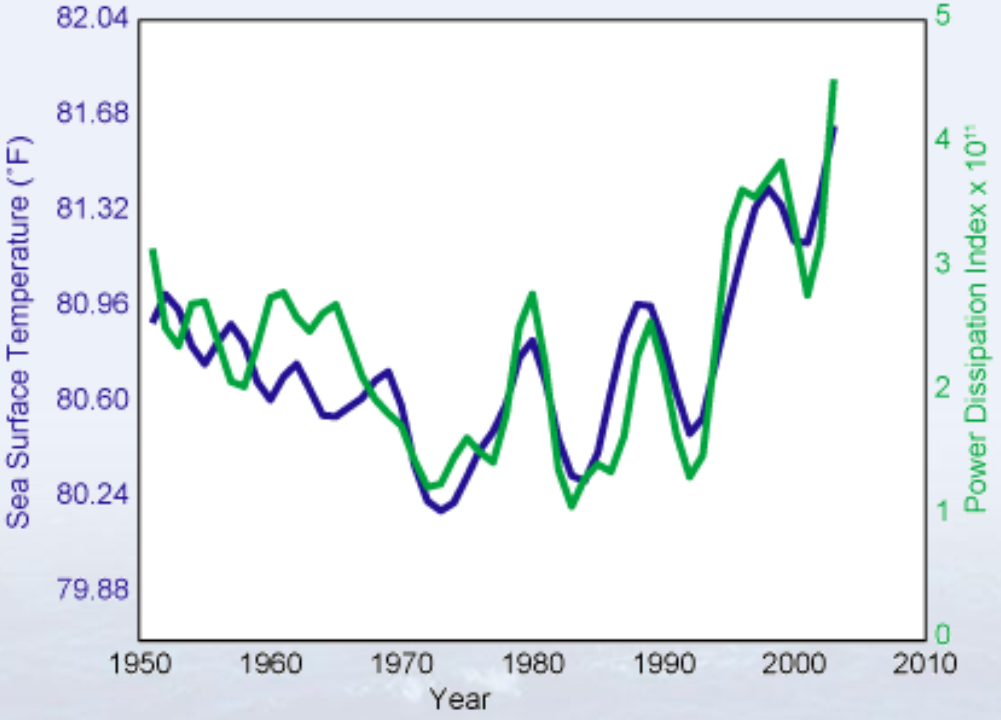
- Hurricanes are complex beasts
  - Strong hurricanes need warm water
    - A necessary but insufficient criterion
      - As illustrated by this figure which is not in our report, courtesy of J. Kossin
  - Many factors influence hurricane growth and development
    - E.g., wind shear

6. Coastal areas are at increasing risk from sea-level rise and storm surge

Hurricane rainfall and wind speeds are likely to increase in response to human-caused warming. Analyses of model simulations suggest that for each 1.8 °F increase in tropical sea surface temperatures, rainfall rates will increase by 6 to 18%.

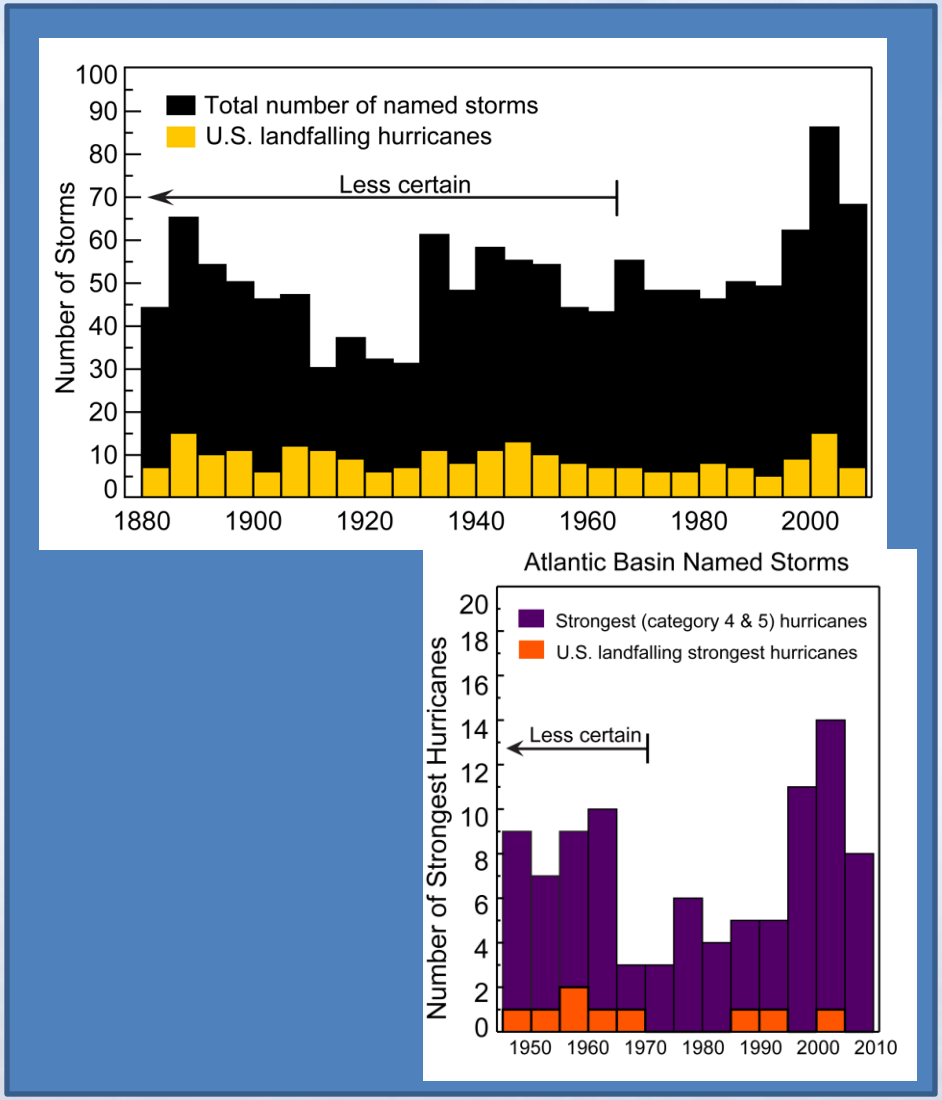
Observed sea surface temperature (blue) and the Power Dissipation Index (green), which combines frequency, intensity and duration for N. Atlantic hurricanes.

Observed Relationship between SST & Hurricane Power in the N. Atlantic Ocean



6. Coastal areas are at increasing risk from sea-level rise and storm surge

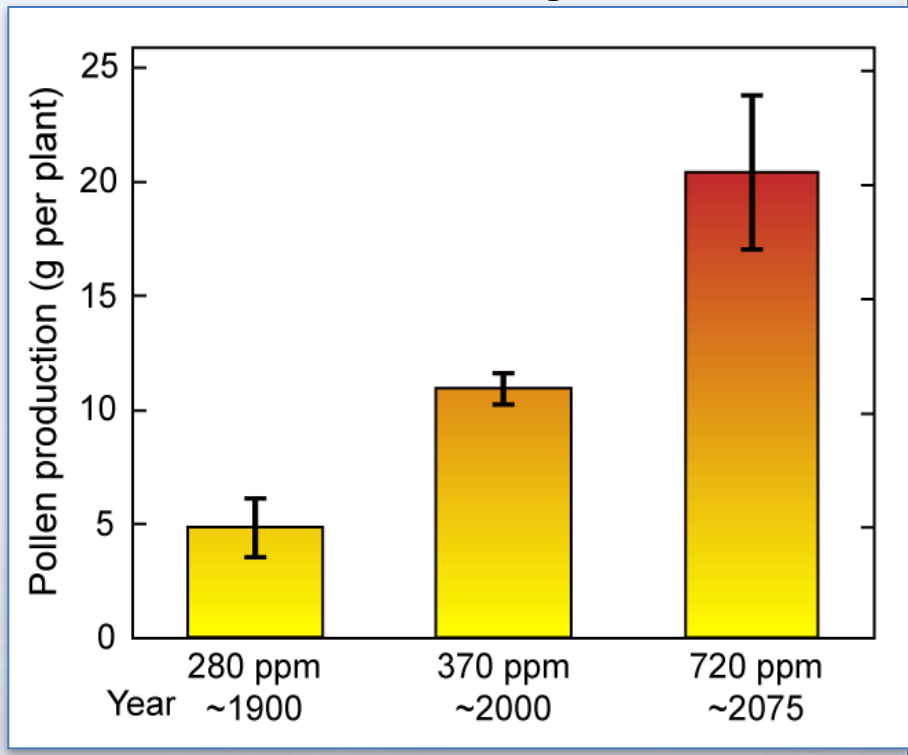
Yet the number of U.S. landfalling hurricanes, shown in yellow, has not increased.



7. Threats to human health will increase

- Heat stress
- Water-borne diseases (due to heavy downpours and higher temperatures)
- Reduced air quality with adverse health effects
- Extreme weather events
- Diseases caused by insects and rodents
- Increased pollen production and prolonged pollen season in a number of plants with highly allergenic pollen

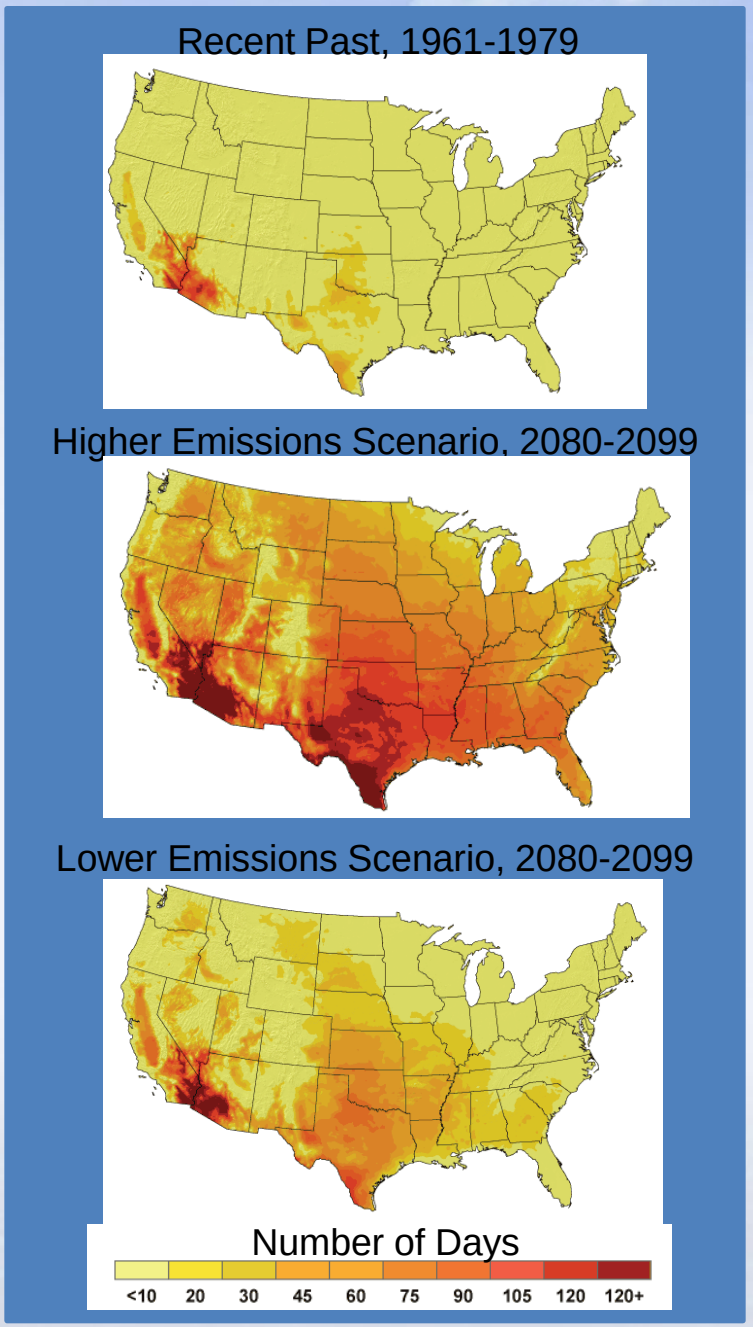
Pollen Counts Rise with Increasing Carbon Dioxide



7. Threats to human health will increase

Observed and Projected Increase in the **Number of Days with Temperature Over 100°F**

- Impacts quality of life, especially in cities, and increases risks of heat-related illnesses

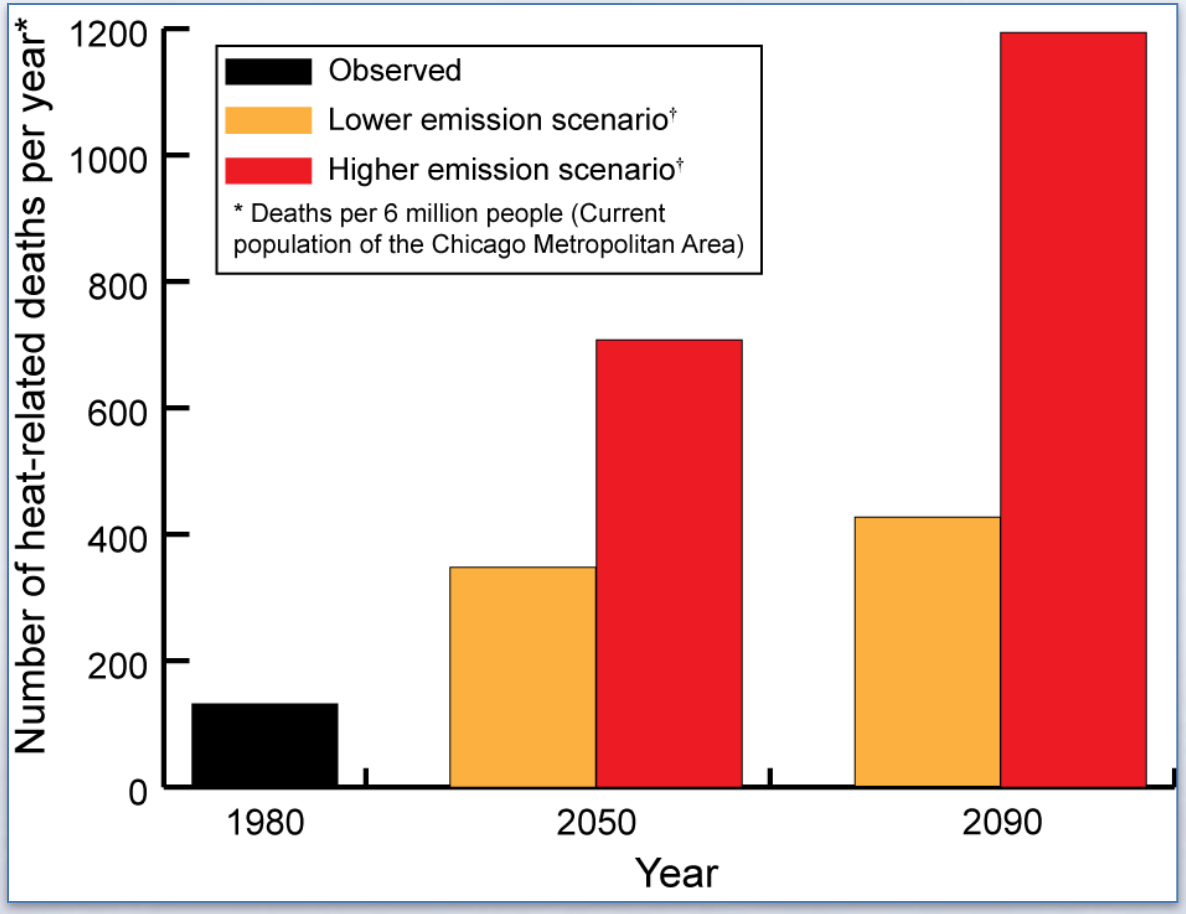


7. Threats to human health will increase

- Significant increases in risk of illness and death related to extreme heat and heat waves very likely

Increases in heat-related deaths are projected in cities around the nation, especially under higher emissions scenarios

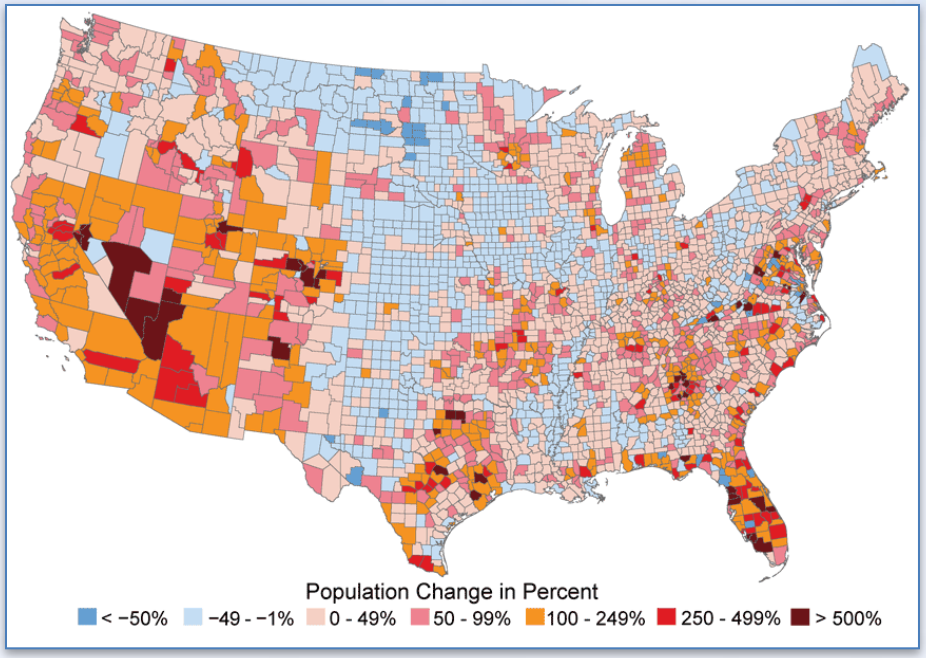
Projected Increase in Heat-Related Deaths in Chicago



8. Climate change will interact with many social and environmental stresses

- Social trends can increase our vulnerability to climate change
  - Concentration of development along vulnerable coasts
  - Aging of U.S. population
  - Increasing urbanization
  - Population growth in Southeast, vulnerable to hurricanes, sea-level rise, and heat stress
  - Population growth in Southwest, vulnerable to increasing water scarcity and wildfires

Population Change, 1970 to 2008



- Impacts on people, infrastructure, and climate sensitive resources and sectors
- Development choices affect impacts of and vulnerability to climate change

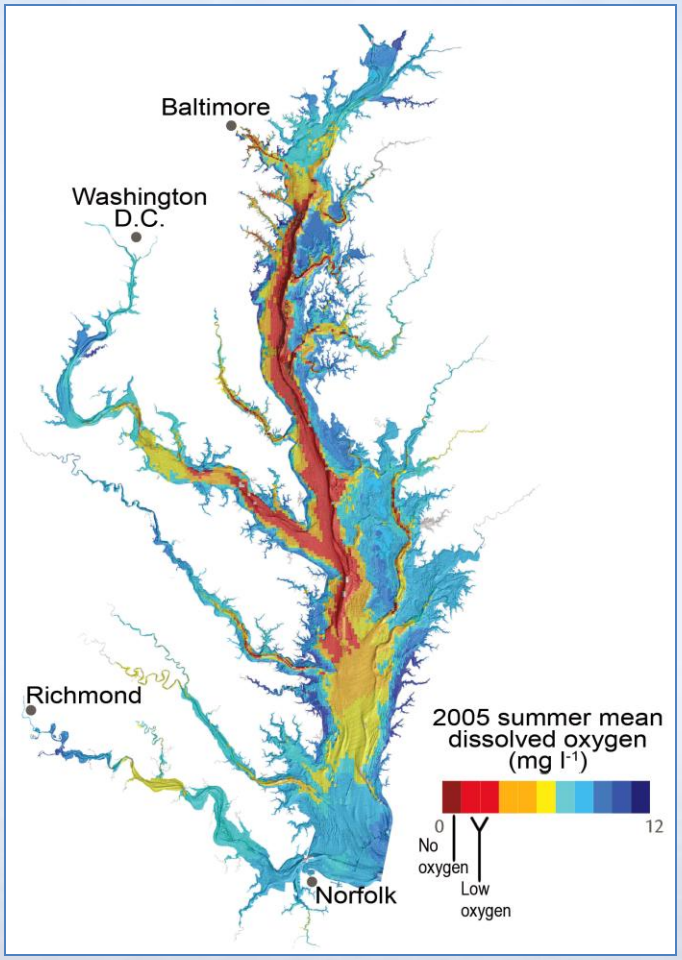
8. Climate change will interact with many social and environmental stresses

- Coastal dead zones likely to increase in size and intensity in Chesapeake Bay and N. Gulf Coast

  Why?
  - Warmer water (less dense)
  - More spring runoff (more nitrogen rich water – fertilizer) leads to:
    - Excess algae and micro organisms
      - Settle on sea floor where they decompose and deplete oxygen from sea water

Adaptation Issue:

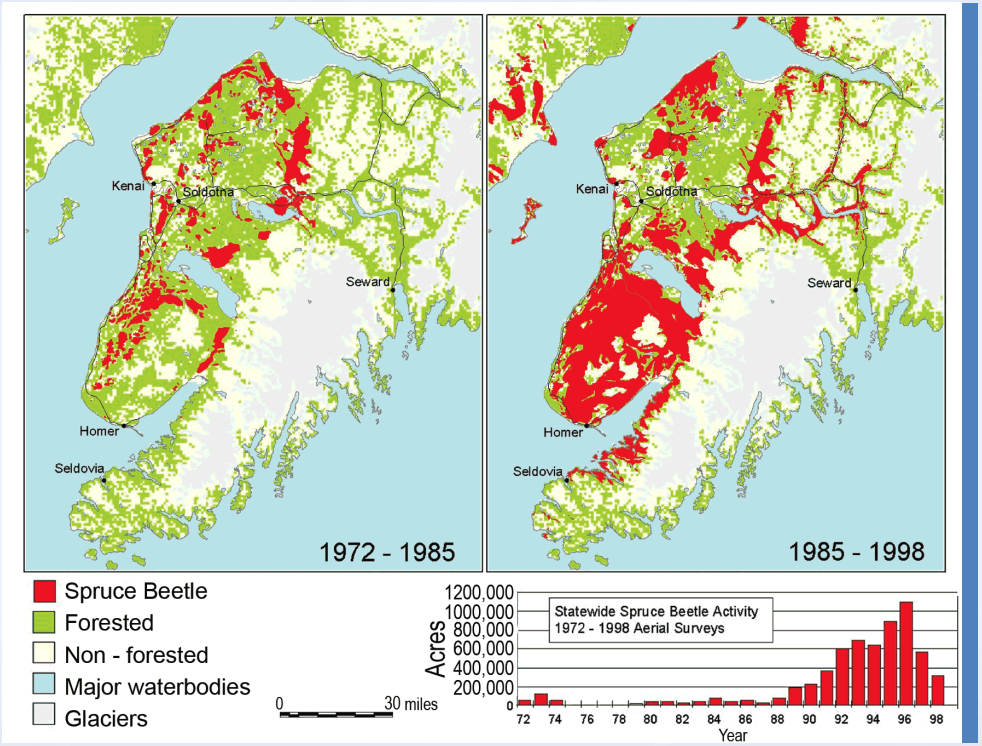
- Reduced runoff from agricultural fertilizer to curb amount of nitrogen rich water



9. Some tipping points will be reached, leading to unpredictable changes

- Thresholds in ecosystems determine growth and survival of species from fish to butterflies to insect pests
- Loss of Permafrost in Alaska changes landscapes: *damage to trees and loss of ponds*
- Air and water temperature increases and loss of sea ice have changed distribution of fish species (Alaska, New England: *cod and lobster*)
- Genetic changes in insects better suited for warm conditions, *e.g.* fruit flies
- Fire frequency and loss of woodlands
- Changes in timing of bird migration

Alaska Spruce Beetle Infestation
Kenai Peninsula, 1972-1998



Over 5 million acres of Alaska spruce forests were destroyed by spruce beetles (red)

10. Future climate change and its impacts depend on choices made today

- Two options (some say 3)
  - Adaptation – to improve our ability to cope with or avoid harmful impacts and take advantage of beneficial ones
  - Mitigation – to reduce emissions of heat trapping gases or increase their removal
- Both are necessary
  - (Third option would be simply to do nothing and suffer)

Adaptation Example

Raising a Sewage Treatment Plant in Boston

- Boston's Deer Island sewage treatment plant was built 1.9 feet higher than it would have been otherwise to account for future sea-level rise.

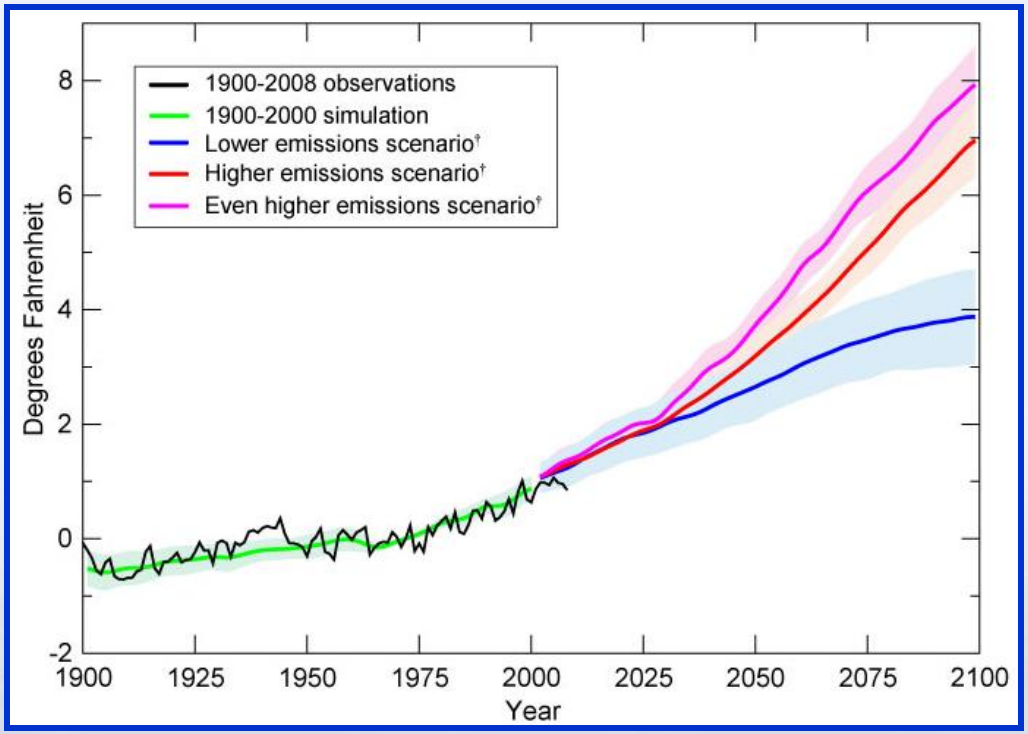
- The planners assessed what could be easily and inexpensively changed later, versus those things that would be more difficult and expensive to change later. Thus, they decided to increase the plant's height, but not to build protective barriers at this time.

10. Future climate change and its impacts depend on choices made today

Mitigation

- Large differences in future climate change projected to result from lower and higher emissions
- Scenarios underscore the importance of mitigation

Observed and Projected Global Average Temperature



Conclusions

Climate Choices

- Choices about emissions now and in the coming years will have far-reaching consequences for climate change impacts
- Reponses to the climate change challenge will almost certainly evolve over time as society learns by doing
- Determining and refining societal responses will be an iterative process involving scientists, policymakers, and public and private decision makers at all levels.


The full report is available from
www.globalchange.gov/usimpacts